

Karst Landscape Preservation

Background

Southern Indiana is home to two well-developed areas of karst landscape, Mitchell Plateau and Muscatatuck Plateau. The Mitchell Plateau intersects three I-69 Community Planning Program counties: Lawrence, Owen, and Monroe. Muscatatuck Plateau is located toward the southeastern portion of Indiana. Karst topography is characterized by fissures, caves, sinkholes, and springs. According to the U.S. Geological Survey, over 25% of the world's population either lives on or nearby karst landscapes or obtains their water supply from karst aquifers.

The formation of karst begins when rainwater reacts with the carbon dioxide in the air. This produces acidic rainwater which filters through the ground and slowly dissolves the limestone or other soluble rock located below, leaving bedrock interrupted by a series of voids, cavities, and cave systems. While karst terrain includes some surface characteristics, such as sinkholes, disappearing streams, cave entrances and springs, these only hint at the vast landscapes that may exist underground.

When managed properly, karst topography provides a number of green infrastructure benefits, including drinking water, groundwater recharge, stormwater storage, open space, animal habitat, and recreation. When ignored, karst terrain poses a natural hazard that can damage private and public buildings and infrastructure and threaten environmental quality and human health. Urbanization or development and other types of land uses can increase the natural hazard risks associated with karst by affecting natural geo-hydrologic processes negatively. These activities can result in sinkhole subsidence or surface collapse, sinkhole flooding, groundwater contamination, and damage to specialized biotic communities. In more practical terms, these hazards can include “structural damage to both private and public buildings (cracked foundations and walls, building collapse, sinkhole flooding damage); increased maintenance costs for infrastructure (sinkhole collapse in roads, [broken underground utilities], pollution of public drinking water sources); pollution of private drinking water sources; and [compromised health of residents as the result of unrecognized contaminants in drinking water] fecal coliform, E.Coli, nitrates, and other pollutants carried in stormwater runoff” (Belo, 2003). While rarely resulting in human fatalities, these hazards may require the regular investment of limited public and private resources to address the constant, minor consequences of these hazards.

Karst aquifers are particularly susceptible to contamination due to the lack of filtration of water entering the aquifer. Contaminants thrown into sink holes can flow directly into the aquifer without filtration, exposure to sunlight, or adequate dilution. Groundwater and surface water in these systems often are connected directly. Some common karst contamination sources include landfills, hazardous waste spills, highway runoff, sinkhole dumps, and agricultural operations. In addition to their extreme vulnerability to contamination, karst aquifers are extremely difficult if not impossible to remediate.

As mentioned above, human activity and pollution of karst landscapes can have a detrimental impact on the biological community thriving within karst areas. There are a variety of fish and wildlife species thriving within sensitive karst habitats and even the slightest disruptions in the delicate balance of these ecosystems can significantly impact this native biota. Threatened karst biota includes several species of endangered bats, ferns, lichens, and invertebrates native to cave environments.

Description

The vulnerability of karst terrain requires special consideration and planning to manage effectively. Many of the same tools available for the protection of groundwater and drinking water can be used directly or modified to address the protection of karst terrain (See Groundwater and Drinking Water Protection tool). Tools are included here only if consideration specific to karst apply.

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Karst Terrain Mapping: Similar to wellhead protection areas, it is necessary to identify and delineate karst areas to ensure appropriate management of these sensitive landscapes. To be most effective this activity can be undertaken by the community and augmented with specific studies for parcels proposed for development. Identification and delineation should include the location, distribution, physical characteristics, evaluation of groundwater quality, and identification of flow patterns. The Indiana Geological Survey (IGS) maintains GIS information for southwestern Indiana counties (counties located south of I-70 and west of State Road 37) as part of the Southwest Indiana Transportation Corridor Project. Karst GIS files are available for download at the Indiana Geological Survey website link located in the helpful references and links section below. These GIS files available include sinkhole areas and sinking stream basins, springs, density of cave entrances, dye lines, and dye points.

Local Hazard Mitigation Planning: Federal law required communities to prepare FEMA-approved hazard mitigation plans to access federal funding provided through the Hazard Mitigation Grant Program. While it is unlikely that funds will be available for the direct mitigation of karst hazards, these plans when prepared in combination with other local tools can help communities to manage this sensitive resource. Local hazard mitigations typically are managed by a group of local stakeholders and stakeholder groups and include the following planning elements: statement of guiding principles and goals, review of local land uses and a history of natural hazard events, a description of all natural hazards found in the community, a discussion of specific hazard mitigation measures, a management structure for at-risk areas that will be managed for ten to twenty years, a description of implementation measures, and a description of the process for evaluation and periodic update (Federal Emergency Management Agency, 2002 in Belo, 2003).

Comprehensive Planning: The incorporation of karst considerations in comprehensive plans can be used very effectively to manage the associated hazards and to protect this important natural resource. Comprehensive plans typically address hazardous areas directly by (1) identifying the hazard areas (see Karst Mapping above), (2) identifying compatible land use activities, (3) establishing construction standards for development, and (4) developing policies for addressing current inappropriate land uses. Less direct, comprehensive plans also may identify less vulnerable areas where development and redevelopment can be encouraged and avoid hazardous areas when planning the siting for community facilities (Belo).

Inappropriate land uses are varied as a result of the specialized nature of these landscapes. Development that requires blasting, is intense, or creates excessive weight can result in subsidence or surface failure. Industrial point sources can contaminate these sensitive systems directly. Waste lagoons, septic systems, intense animal agriculture, underground storage tanks, and landfills can contaminate karst aquifers directly and/or upon subsidence or surface failure. Land uses that change the local water tables such as well pumping, modification of natural drainage patterns, and inadequate storm-water management can accelerate sinkhole subsidence and increase sinkhole flooding.

Karst-related Overlay Zoning Districts establish additional development standards that apply over and above base zoning. Overlay districts are a useful tool for the protection of this specialized resource because karst areas often have irregular boundaries that typically do not match underlying zoning districts. Communities typically define a karst overlay district as the area corresponding to the location of underlying bedrock. A variety of treatments are used in conjunction with overlay districts, including:

- **Karst Feature Buffers** restrict development around a karst feature by establishing a fixed radius or delineated area around the feature. This strategy helps both to reduce non-point source pollution by maintaining vegetation and tree cover and to reduce the risk of subsidence and sinkhole flooding. Some communities establish varying buffer requirements based on specific karst features and the relative hazard risk associated with them.

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- **Geotechnical Studies** provide specific information relative to karst and a proposed site by identifying surface and subsurface soils, geology, and hydrology. These studies often are conducted in two phases: a preliminary site investigation and a site-specific investigation.
- **Performance Standards** provide flexibility regarding the specific actions to be taken to achieve local goals. For karst areas, performance measures may include maintaining predevelopment stormwater runoff quantity and quality, stricter effluent standards for septic systems, and the protection of wellheads.

Capital Improvements Planning: The location of public infrastructure often drives development. Capital improvements plans typically include a prioritized schedule of future capital improvements (roads, sewers, and drinking water lines) for a multi-year period. Each proposed project typically is accompanied by cost estimates and a proposed source of funding. Communities can develop CIPs strategically to steer development away from sensitive environmental areas, such as karst terrain, and toward less sensitive areas. This management tool does not directly prohibit development in the karst terrain, but may discourage the type and intensity of development. See Capital Improvements Planning tool.

Anti-dumping Ordinances: Historically, sink holes have been used in rural areas to dump trash and household hazardous waste. This practice can lead to groundwater contamination and sinkhole flooding. Household chemicals flow directly to groundwater. Trash diminishes sinkhole flood plain capacity. Ordinances prohibiting dumping combined with public education about karst landscapes are important tools for the protection and management of these landscapes.

Enhanced Septic System Regulations: Because failing septic systems are an increased hazard in these landscapes, enhanced regulation of these systems is appropriate. Typically, enhanced regulations include increased minimum setbacks from sinkholes and cases, increased separation distance between septic system drainage fields and bedrock, mandatory periodic maintenance, and the reservation of an additional drain field.

Public Education: Public education is critical to the management and protection of these complex and often hidden landscapes. Residents must understand the dumping and certain land use activities can have significant consequences in near and seemingly distant locations. Poor management can result in damage to private property as the result of sinkhole subsidence or flooding

Relevant Statutes

No relevant statutes were identified for this tool.

Capacity Recommendations

Karst protection planning generally requires the assistance of a qualified expert to perform the hydrology studies necessary to delineate protection areas and specific risks. Zoning and other land use regulations require that communities have a plan commission as well as a comprehensive plan. The implementation of more sophisticated regulatory treatments under zoning and local health regulations, such as establishing performance standards, also may require in-house or contract technical experts.

Guidelines / Considerations for Implementation

- Karst protection can be complex and sometimes costly. It is important for communities to weigh the costs and benefits of certain protection measures. It is also critical to consider the extreme difficulties associated with corrective action when deciding on the extent of protection.
- Consider management alternatives by evaluating local conditions and needs, public input, public tolerance for regulation, financial and social costs, economic development interests, and capacity for implementation and enforcement.

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- Consider the use of regulatory and non-regulatory techniques to protect water quality. Because individual behavior can affect water quality significantly, non-regulatory tools such as public education are critical.
- Ensure local “ownership” and gain public support for the wellhead protection program and implementation measures to increase its chances of success.

Example Ordinances

No example ordinances are available for this tool.

Example Studies

- **Protecting the Edwards Aquifer-Urban Development BMPs in Central Texas** [<http://www.epa.gov/owow/NPS/Section319II/TX.html>]: The Edwards Aquifer is a large Texas aquifer located below nine counties. The aquifer has extremely rapid recharge due to karst features and rapid groundwater movement. This case study exhibits the continual efforts of the State of Texas and the Texas Natural Resource Conservation Commission in protecting the Edwards Aquifer through regulated development, revising Texas Administrative Code to regulate nonpoint source pollution in the recharge zone, requiring a Water Pollution Abatement Plan from anyone seeking to develop in the recharge zone, and education of developers, construction staff, engineers, and water quality specialists in the prevention of nonpoint source pollution.

Helpful References and Links

- **Natural Hazard Mitigation Planning for Karst Terrains in Virginia (Belo, 2003)** [<http://scholar.lib.vt.edu/theses/available/etd-05222003-230312/unrestricted/etd.pdf>]: This master’s paper provides information about karst hazard mitigation in Virginia, including information on typical management and regulatory options and their use in Virginia.
- **Living With Karst: A Fragile Foundation (George Veni, et al., 2001)** [<http://www.agiweb.org/environment/publications/karst.pdf>]: This American Geological Institute publication provides practical guidance for living in karst areas, including information about the nature of karst terrain, typical problems and their causes, and measures to mitigate or prevent those problems.
- **Indiana Geological Survey - Karst in Indiana** [<http://igs.indiana.edu/Geology/karst/karstInIndiana/index.cfm>]: The Indiana Geological Survey provides information on karst areas in Indiana, features and characteristics, and contamination threats. IGS also maintains GIS information for southwestern Indiana counties (counties located south of I-70 and west of State Road 37) as part of the Southwest Indiana Transportation Corridor Project. Specific GIS information about karst GIS files is available for download at http://129.79.145.7/arcims/statewide_mxd/dload_page/hydrology.html.
- **“Recommended Best Management Practices for Proposed Activities in Karst Areas-Oklahoma”** [<http://www.fws.gov/southwest/es/oklahoma/karst.htm>]: This U.S. Fish and Wildlife Service website provides technical information about karsts in Oklahoma as well as a number of best management practices that can be applied in Southwest Indiana.
- **National Park Service-U.S. Department of the Interior—Cave and Karst Program** [<http://www2.nature.nps.gov/geology/caves/program.htm>]: The Cave and Karst Program website provides information about the importance of caves and karst, potential threats, cave and karst management, and links to other federal agencies involved in karst conservancy.
- **U.S. Geological Survey Karst Information** [<http://water.usgs.gov/ogw/karst/>]: The U.S. Geological Survey provides background information on karst landscapes, karst photos and maps, and USGS Karst Interest Group Proceedings, which contains information on aquifer hydraulics in karst systems, cave and spring species and habitats, and contaminant transport.

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- **Indiana Karst Conservancy** [<http://www.caves.org/conservancy/ikc/index.html>]: The Indiana Karst Conservancy (IKC) is a non-profit organization dedicated to the preservation and conservation of Indiana's unique karst features. The IKC website contains information about what karst is, the policy for oil and gas drilling in Indiana karst, Indiana's cave regulations, and cave management policy for Indiana state properties.
- **Cave Biota Documentaries** [<http://www.cavebiota.com/>]: Caves and karst provide a habitat for a variety of species. The Hoosier National Forest and the Indiana Karst Conservancy has sponsored the Cave Biota online documentaries about cave and karst ecology.
- **The Karst Conservancy** [<http://www.karstconservancy.org/karst/what-is-karst.asp>]: The Karst Conservancy is a non-profit, national level land trust established to protect karst areas. The goal of this organization is to increase the conservation of karst areas. The Karst Conservancy protects important karst properties by directly acquiring them, holding conservation easements, and using other tools that permanently protect the land. Their website provides information about what karst is, potential threats, hidden landscapes, and a variety of photos of karst landscapes.
- **Karst Waters Institute (KWI)** [<http://www.karstwaters.org/index.htm>]: The Karst Waters Institute is a 501(c)(30) not for profit organization working to educate the public and professionals on karst water systems. KWI supports this mission through sound scientific research. The KWI website contains information regarding what karst is, karst water quality, karst geology and ecology, upcoming conference information, teacher resources, and karst resource links.
- **Project Underground** [<http://www.dcr.virginia.gov/underground.shtml>]: Virginia Department of Conservation & Recreation - Project Underground is a cave and karst awareness and education program that provides workshops and in-service training programs. The workshops and materials are designed for classroom teachers, cavern, park, museum, and nature center staff, or any youth-oriented group leaders.
- **National Speleological Society (NSS) Bookstore** [<http://nssbookstore.org/>]: The National Speleological Society provides publications, journals, National Cave Management Symposium proceedings, and references for teachers.
- **Management Recommendations for Construction Projects Affecting Karst Habitats (2001)** [<http://www.conservation.mo.gov/documents/nathis/endangered/karst.pdf>]: This Missouri Department of Conservation information sheet provides best management practices to manage the non-point source pollution and sediment associated with construction sites.
- **"Creative Partnerships for Karst Protection-'How to'"**(Kriste Lindberg, 2004) [<http://www.wvcc.net/news-item.asp?id=103>]: This online abstract of a presentation at Conservancy Forum 2004 hosted by the West Virginia Cave Conservancy provides brief information about the importance of partnerships in successful karst protection and a process for behavior change as awareness, education, and acceptance. It references a protection effort by the City of Bloomington, Indiana and their efforts in informing citizens about karst and encouraging community involvement.

Helpful Contacts

- Indiana Karst Conservancy [<http://www.caves.org/conservancy/ikc/>]
 - o Richard Vernier, President
 - o Kriste Lindberg, Chairman of the Education and Outreach Committee, lindberg@kiva.net
- Virginia Department of Conservation and Recreation
 - o Joey Fagan, joseph.fagan@dcr.virginia.gov

Funding Sources

No other funding sources have been identified for this tool.

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Program Objectives and Issues Addressed

- Protecting natural resources
- Infrastructure planning
- Protection of drinking water supplies
- Protect public health
- Protecting habitat
- Protecting karst terrain

See Also

- Groundwater/ Wellhead Protection